CHAPTER 3

PERMIAN OUTCROP DESCRIPTIONS

3.1 DIAMICTITES AND SIMILARLY POORLY SORTED SEDIMENTS

3.1.1 WOORAGEE VALLEY DEPOSITS (see map 1 in pocket)

Permian glacial deposits crop out about 6 km NE of the town of Beechworth in the Wooragee Valley, but the deposits are more extensive than indicated on either the provisional geological map of the Beechworth district (Mines department 1974: Beechworth 1:50 000 provisional geological map, sheet 8115-III. or the 1974 : Wangaratta 1:250 000 geological map, sheet SJ 55-2, Ed.2).

The valley is relatively small and deposits are distributed over an area of 25 km^2. Outcrop is poor and considerable traversing was necessary to verify the extent and nature of the deposits. Only small isolated patches crop out on the valley floor. One area along the course of Magpie Creek toward the western end of the valley has sufficient outcrop to permit the construction of a rather rough stratigraphic column.

Glacial deposits were first noted in this area by Dunn (1887). Outcrop extends from GR. 750835 to GR. 754823 (Royal Australian Survey Corps [ed.1] 1971, sheet 8225: series R625: topographic map 1:100.000). The relationship between the Magpie Creek deposits and

others elsewhere in the valley is not altogether clear, nor are the true thicknesses of any of the deposits well established. Outcrop is almost entirely restricted to the creek bed and its slumped and vegetated banks. Bedding planes are distinct and appear to be near horizontal but dips up to about 15° NW, SE and SW are recorded. Cross-bedding is infrequent, ill-defined and small scale (troughs are 2 cm to 3 cm deep). Detailed measurements are not possible in all cases and for some troughs only a sense of current motion can be defined, which varies from SW to W and N.

Diamictite outcrops mainly in creek beds and is texturally quite variable but sandy silty conglomeratic textures are common. Clasts range from granule to boulder size. Minor sandstones and siltstones are also associated with the diamictite outcrops. Surface concentrations of the gravel fraction from weathered diamictites also occur in the valley. Only a few road cuttings in the Wooragee Valley expose in-situ weathered rocks. In the fields immediately adjacent to the cuttings concentrations of the "lag" gravels can be found. Pebble sized clasts are the most common in the valley diamictites and "lag" gravels. Clast lithologies include coarse, medium and fine grained sandstone. Indurated varieties are most common: reddish, brownish and yellowish micaceous sandstones are rarer. Black, dark brown and caramel coloured cherts are also present together with a small range of metamorphic rocks.

3.1.1.1 THE MAGPIE CREEK BEDS

A pictorial representation of the Magpie Creek beds is shown in figure 2, p.66 The lowest part of the section is exposed in the bed and banks of Magpie Creek, about 150 m S from the point where the

Beechworth-Albury road crosses the creek. The first outcrop shows about 1 m thickness of silty-pebbly, very fine sandstone. Pebble sized clasts are dominant in the gravel fraction and are within the limits of 10 mm to 40 mm. Some cobbles and boulders are present but uncommon at this site. Clasts are mainly varieties of indurated sandstone but some are clear or milky quartz. Cross-bedding is generally ill-defined and on a small scale (2 cm to 4 cm). A few trough plunge directions can be identified (194°,204° and 219°). The upper weathered part of the exposure blends with the overlying alluvium; careful observation shows that the contact plane is indicated by a sub-horizontal line of rounded, pitted, milky quartz pebbles. A few slightly undulose clay-filled surfaces are probably joint planes. Their attitudes are about $20^{\circ}/209^{\circ}$.

A second discontinuous outcrop (upstream) consists of about 1 m of gravelly, very fine sandstone with similar coarse fraction characteristics to those of the first exposure. Near planar surfaces, interpreted as bedding planes have attitudes of $15^{\circ}/149^{\circ}$.

About 2 m of uniformly grey siltstones or very fine sandstone crops out at the third exposure. The siltstone is unbedded and and it is overlain by about 1.5 m of alluvium which is probably the Quaternary deposit indicated on the published geological map. Some planar surfaces present in the siltstone have an attitude of about $17^{\circ}/209^{\circ}$.

The fourth exposure is in the Magpie Creek channel adjacent to a windmill, about 65 m south of the previous exposure. Massive fine to very fine silty sandstone is overlain by fine to very fine, pebbly (about 20%) sandstone. Both beds are unconformably overlain by Quaternary alluvium which is distinguished by the presence of a sub-horizontal and sub-parallel, pitted milky quartz pebbles. The

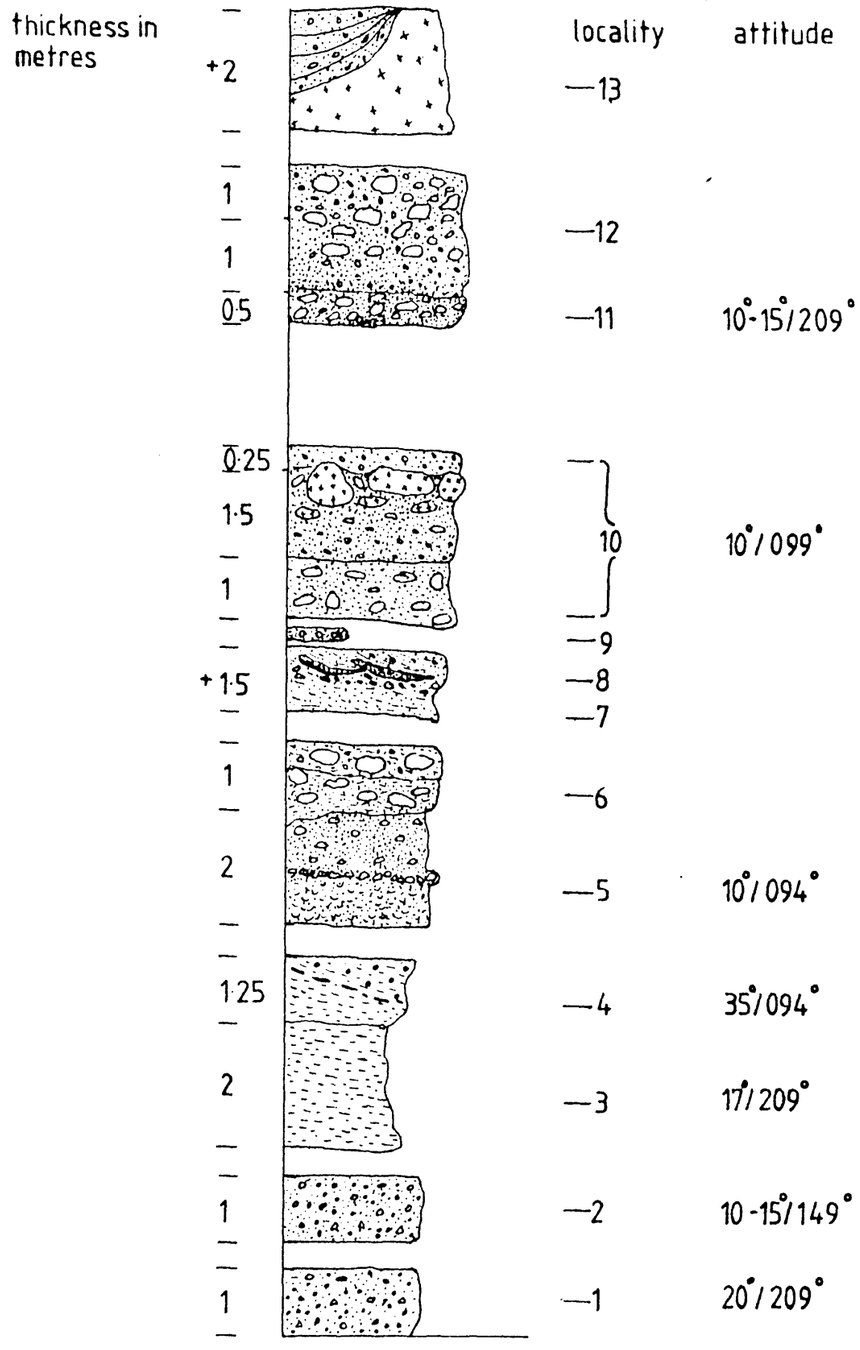
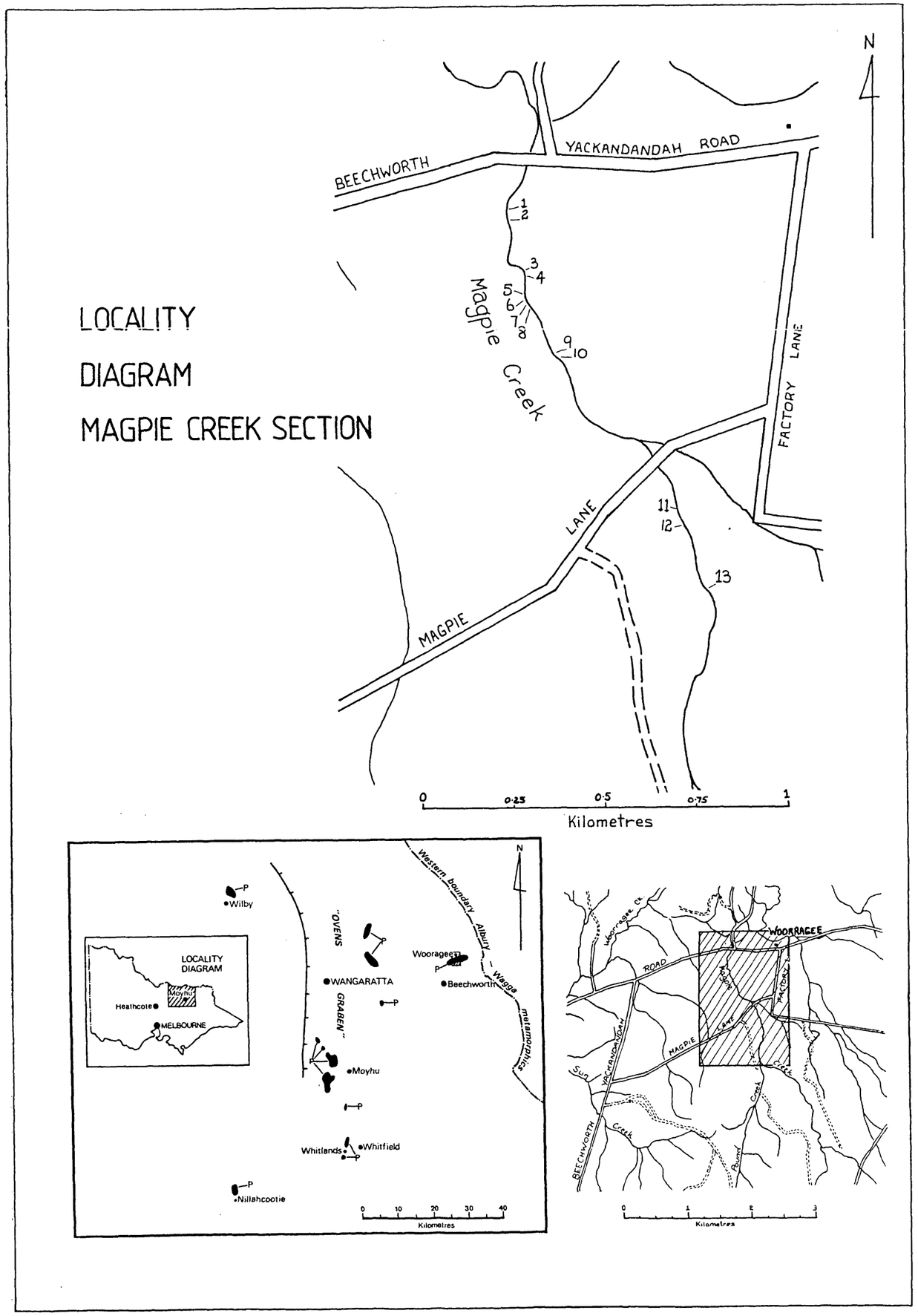


Figure 2 Magpie Creek stratigraphic section



pebbles in the bed below the alluvium are composed mainly of sandstones and cherts; they are between the size limits of 20 mm and 40 mm. The dominant shapes according to the Zingg classification (Zingg, 1930) are spheroids and probably rollers followed by discs. This upper unit is separated from the lower massive very fine silty sandstone by a distinct plane interpreted as a bedding surface. The attitude of this plane is about $35^{\circ}/094^{\circ}$ and it is filled with a grey plastic clay. The clay merges with the matrix of the overlying unit but stops abruptly at the base plane separating the two units. Both units are about 0.75 m thick. The only sedimentary structure observed at this locality is a scour and fill structure which is about 30 cm wide and about the same maximum thickness. It appears to deepen in direction 224°.

About 5 m south from the fourth locality, beyond a fence near another windmill, an outcrop of medium to fine grained sandstone forms the lowest visible unit at the fifth locality. Vague cross-bedding is outlined by the presence of very coarse grains coated with blue-black iron oxide. Grain size varies from about 1 mm to 2 mm. The entire bed is about 1 m thick. More outcrop, although eroded, is almost completely concealed beneath the creek bed and is below the waterline. The cross-stratified portion of the unit changes vertically to become a layer of sandy gravel. Some portions are coarse-sandy pebbly gravel: (*** note the descriptive terms used are standard terms used with grade scale nomenclature, e.g. Folk, 1955) the pebbles are between 10 mm and 100 mm. This coarse layer is also about 1 m thick. From visual estimates, the proportion of pebble shapes are:

* Spheroids - 80%;

* Rollers - 15% and

* Discs - 5%.

One planar surface is highlighted by an abrupt change from coarse to fine grains and has an attitude of $10^{\circ}/094^{\circ}$. In the same area a small outcrop in a 2 m wide gulley, the sixth exposure, appears to be stratigraphically higher than the previous beds. The gully follows a fence line which runs east-west about 3 m south of the second windmill and enters from the western bank of Magpie Creek. The outcrop forms the northern undercut bank of the gulley and is partially covered by debris and is partially under water. About 1 m is exposed in the northern bank but only about 0.5 m is well exposed. The lower part of the exposure consists of weathered diamictite with a coarse to very coarse sandy pebbly conglomeratic texture. Overlying this unit is a better exposed similar but more cobbly diamictite.

The seventh exposure shows a change in character of the deposit because the finer fraction contains more fine sand silt and clay. Pebble and cobble sized granitic clasts are present which were not found lower in the section. Some are present as weathered ghosted forms. Others are so badly weathered they now have the appearance of rounded patches of clay in which grains of quartz are dispersed. The relative proportion of different pebble shapes is generally similar to the previous exposure except that the proportion of spheroids is a little higher (90% rather than 80%). The outcrop is wedge-shaped and extends laterally for about 10 m. A few metres upstream the matrix changes from a very fine sand and silt to more sand and less silt. The total thickness of this exposure is about 1 m.

The number of granitic clasts increases at the eighth exposure and clasts range from 100 mm to 300 mm. Despite there being outcrops of Devonian granite upstream which are releasing gravel into the creek, there is no doubt that the clasts observed at this exposure are part of the outcrop. contained within 0.5 m of weathered conglomeratic textured outcrop are four distinct lenses of medium to coarse grained sand with the form of wide but shallow cross-beds; one lens is clearly truncated by the uppermost. The cross-bed trough plunge direction is 179°. The total thickness of the eighth exposure is at least 1 m.

The ninth outcrop is about 1 m long and about 1 m thick and is probably a continuation of the upper part of exposure eight. From visual estimates, granite clasts make up about 5% of the pebbles and cobbles. Even though the exposure is quite small, some cross-bedding structures are visible. Three troughs plunge in direction 179°.

Stratigraphically above outcrop nine is a small sequence of beds which form the tenth exposure. The lower bed is a very fine sandstone with a sightly gravelly base. The sandstone appears to envelope or partially enclose granitic cobbles and boulders. Some of the boulders are between 0.5 m and 1.5 m in diameter. The lowest sandstone is about 1 m thick and has a bedding attitude of 10°/099°. It is overlain by about 0.25 m of sparse pebbly, sometimes granule medium to fine sandstone.

The eleventh exposure, 5 m long, is still within Magpie Creek but is much further upstream; it is about 100 m beyond a fork in the creek along the western arm, just S of a culvert where Magpie Lane crosses Magpie Creek. The lowermost bed is conglomeratic and about 0.5 m thick. It is overlain by about 1 m of pebbly fine sandstone with dips between

10° and 20° in direction 209°.

The twelfth exposure, further upstream, consists of a bed of sandy pebbly cobbly conglomerate with no definite bedding. Boulders and cobbles (about 50% granitic) comprise about 40% of the coarser than sand fraction. Rare fossiliferous cobbles and boulders are also present (see sample 77/5).

The final exposure, thirteen, which completes the account of the Magpie Creek sequence is located close to a wooded area (GR.754811; Royal Australian Survey Corps [ed. 1] 1971, sheet 8225 series R652, topographic map 1:100.000). A sandy clayey gravel textured bed nonconformably onlaps Devonian granite. The dip of the nonconformity is about 30° N. Grain size varies from coarse sand (about 0.5 mm) to boulders but sandy silty conglomeratic textures are common. Clasts about 300 mm). Medium and finer sand, silt and clay are also present but in small amounts. The modal grain size is between granule and very coarse sand. The bed is not very indurated and is over 2 m thick.

3.1.1.1.1 <u>SUMMARY</u> -

The section appears to be characterised by a series of upward fining cycles; the cycles do not start with the same grain sizes each time. No specific changes are noted in the clasts through the section other than granitic clasts becoming more prevalent toward the top of the section. The finer grain sizes are more common toward the middle and bottom of the section. Generally patterns are difficult to see except for the cyclical patterns on a broad scale.

3.1.1.2 OTHER LOCALITIES WITHIN THE WOORAGEE VALLEY

The Magpie Creek section, although far from ideal, is the most complete section available within the valley. There are a number of small outcrops which are not permanent and are periodically uncovered by the changing erosion patterns within the channel. Three other outcrops occur in an unnamed creek, east of Magpie Creek. Silty very fine sandstone crops out in the western fork of the creek and is about 2 m thick. The outcrop is not very extensive and is only about 3 m long. This first exposure(GR.76289; Royal Australian Suvey Corps [ed. 1], 1971 sheet 8225, topographic map 1:100.000) shows some bedding planes with attitudes of $15^{o}/114^{o}$ and $15^{o}/329^{o}$.

The second area of outcrop (GR.762830, same map) occurs at a junction of two arms of the creek. Here about 1 m of silty, clayey, very fine sandstone is present containing grains between 1 mm and 5 mm in diameter. Underlying the sandstone is another bed of about the same thickness (1 m); it is a silty sandy gravelly conglomerate. Besides the usual indurated sandstones, granitic pebbles are also present within the coarse fraction. The granites are pinkish in colour and are similar to those located in exposures seven to twelve from Magpie Creek. The pebbles in this bed have long axis orientations of about 049° and bedding planes have orientations of about 10° to $15^{o}/149^{o}$. The remaining outcrop is located in the creek bed, downstream to the north (GR.762833, same map), near where a fence meets the creek. Although poor, there is almost continuous outcrop in the creek bed and in the banks along the waterline between this and the previous locality. The uppermost unit consists of silty clayey very fine sandstone and in places an underlying silty sandy gravelly conglomeratic bed crops out.

About 800 m NE of these exposures, another two outcrops occur. They are located in another creek which flows from the east to join Reedy Creek further to the north. The banks of the Reedy Creek tributary (GR.768836, same map) consist of about 2 m of almost completely weathered sandy pebbly conglomerate which crops out SE of a farmhouse. The farmhouse is about 400 m E of Factory Lane; along the Beechworth-Yackandandah road. Most of the pebbles within the conglomerate are indurated sandstones. Overlying the conglomerates are younger unconsolidated gravel deposits which are probably the already mapped Quaternary alluvium.

Upstream, about 40 m (GR.769836, same map), 2 m of silty sandstone crops out and extends for about 5 m forming part of the southern bank of the creek. Grading with normal upward fining cycles occurs in fine to medium grained sandstone. Layers of about 5 mm to 10 mm thick fine upward over and additional thickness of about 5 mm to become very fine sandstone. The upper surface of the very fine sandstone is undulose and has an amplitude of about 2 mm. Medium to coarse sandstone begins the next upward-fining cycle. The graded beds are part of an outcrop which is very weathered and although the outcrop is about 2 m high and about 3 m long, grading is only visible with an area of about 900 mm^2 in the centre of the bank.

The gross appearance of the outcrop is layers of very fine sandstone overlain by medium to coarse sandstone containing 2 mm to 5 mm well rounded pebbles; in turn overlain by very fine sandstone followed by medium sandstone. Bedding at the western end has an attitude of $15^o/109^o$ whereas at the eastern end, large scale trough cross-beds have a plunge between 2° and $8^o/344^o$.

Other outcrops are present in a few valley road cuttings. Most lithologies are quite weathered and occur in the middle and eastern parts of the valley. The outcrops mostly consist of reddish to brown sandy pebbly clay, sometimes containing cobble sized clasts which are as very well rounded as the pebbles. The pebbles and cobbles are predominantly spheroidal shaped except where the parent rock type has some predisposition to split into layers; thereby increasing the likelihood of disc and blade shapes. Weathered similar outcrops occur at the end of Star Lane about 500 m S of the Beechworth-Yackandandah road (GR.778832, Royal Australian Survey Corps [ed. 1], 1971 sheet 8225, series R625 topographic map, 1:100.000) and along a portion of the Beechworth-Yackandandah road(GR.750835 to GR.779837, same map). At the Star Lane cutting, pebbles consist of indurated occassional fossiliferous sandstones and rarer granitics but all are very well rounded and of medium to high sphericity, and are between the size limits 50 mm to 150 mm. Cobbles and boulders occur on the SW side of a hill toward a creek (GR.778832, same map). The fossiliferous clasts contain numerous fragments of crinoid stems as well as separate ossicles and rarer fragments of brachiopod shells. The surrounding ungrassed patches on the hillside reveal reddish-brown soils containing many pebbles and granule sized grains.

Further N (GR.779837, same map) the road cutting at the intersection of the Beechworth-Yackandandah road and Star Lane shows reddish brown weathered pebbly sandy clay with occassional small cobbles. In various parts of the cutting face there is a faint layering on a scale of about 2 cm. It alternates from a reddish colour to a bleached grey. Colour banding is the only indication of layering in the cutting; the lateral extent of the banding is about 15 cm and is inter-

preted as a weathering phenomenon.

The cutting also shows a palaeochannel cross-section which is about 25 m wide and about 2 m deep (see plate 6, p.75). The channel contains a high proportion of pitted milky quartz pebbles; some are quite well rounded.

A recently modified cutting (GR.745834, same map) shows massive gravelly sandstones overlain by angular alluvium. These deposits below the alluvium are part of the central Permian deposit appearing on the Wangaratta geological mapsheet (SJ 55-2, 1:250.000). The overlying alluvium/colluvium is also mapped and appears to be part of mapped Quaternary deposits.

The remaining outcrops deserving mention consist of surface concentrations of pebbles cobbles and boulders. About 1 km E of the intersection of Magpie Lane and the Beechworth-Yackandandah road, fields (GR.730816, same map) just E of a farmhouse contain a wide variety of pebbles and cobbles. Many clasts have been heaped by the local farmer in a bid to rid his fields of what is generally regarded in the district as the ever appearing menace. Such practices are common in areas containing similar Permian deposits in Victoria. The clasts near Magpie Lane consist of the usual indurated sandtones and rarer cherts, and are between 10 mm and 600 mm in diameter. The indurated sandstones are mostly medium grained varieties; some coarse grained varieties have been found. Micaceous sandstones with reddish to dark brown colours occur but are rare and resemble Carboniferous lithologies of the Mansfield Basin further SW. They also resemble clasts found in and adjacent to the Ovens-King River Valley. The chert clasts consist of a variety of colours but are usually black through to pale brown or

Plate 6 The Beechworth - Yackandandah road cutting at the Star Lane intersection showing a Tertiary palaeochannel 25 m wide - 2 m deep in weathered diamictite. (GR. 779837, RAS, sheet 8225, 1971,) (1:100 000)

caramel. Very weathered acid igneous clasts are also present but are rare.

Numerous striated pebbles cobbles and boulders are exposed at this site but are rarer at other sites. The striae are multi-directional; faint on some clasts and very clear on others. The clarity of striae is doubtless a combined function of the original depth of scoring, the relative hardness of the host rock type and the subsequent transport and weathering history. Fossiliferous clasts are relatively rare at this locality but their existence is of great importance.

About 700 m NE along Magpie Lane, just beyond the previous locality, thick grey plastic clay contains well rounded sandstone boulders and forms the wall of a small farm dam. The wall material is mostly gravelly clay. Immediately N across the road, another farm dam is constructed of similar clayey deposits except that there are more pebbles. These pebbles are mostly sandstones which are medium to fine grained with colours varying from pale grey to caramel. Micaceous sandstones are again present together with cobble sized pieces of partially cemented conglomeratic sediment which resembles those sediments cropping out in Magpie Creek. This second dam is at the head of a small ephemeral watercourse which flows N eventually into Reedy Creek. Further along the watercourse a small earth bridge (GR.74827, same map) shows clay rich wall material containing gravel sized clasts. An estimated 50% of pebbles at the surface are sandstones. Metamorphosed fine grained sediments similar to those of the Ordovician of this region comprise about 30% of the gravel fraction. The remaining 20% consists of cherts, jaspers and vein quartz. In the easternmost part of the Valley (GR. 787830, same map) on a hill close to an old dismantled

railway line, striated often fossiliferous pebbles and cobbles occur. The fossiliferous remains are as usual dominated by crinoid stems and separate ossicles and rarer brachiopod fragments. On the ungrassed portion of the hillside, especially at the gateway on the western side of the hill, reddish-brown to grey rich soil is exposed; small pebbles frequently protrude from within erosion rills.

3.1.2 THE SOUTHERNMOST PORTION OF THE OVENS-KING RIVER VALLEY (map 3)

Many localities in this area have been reported in the literature but few have been described in any detail nor have their locations been adequately identified. The Ovens-King River Valley is quite a large topographic feature and it includes the northern portion of the King River Valley. Altogether the total area involved covers about 650 km^2 which is about 25 times larger than the area of the Wooragee Valley. Even so, the outcrop is still as scarce as in the Wooragee Valley and the glacial deposits equally difficult to recognise because of agricultural modification, deep weathering and localised mass movement. Outcrops are generally limited but even though they are small they are important when piecing together the nature and distribution of glacial deposits of the region.

Already mapped deposits (Dunn, 1871) 5 km SE of Springhurst (GR.443525, Royal Australian Survey Corps [ed.1] 1968, sheet SJ 55-2, series R502 topographic map 1:250.000 with 1972 amendments) consists of surface concentrations of cobbles, pebbles and boulders: cobbles and boulders account for about 10% to 15% of the deposit. The clasts include chert, sandstones and igneous rocks. No striated or fossiliferous clasts were located at this site; perhaps this was a function of the relatively short time I spent searching for them. A cluster of

rounded boulders is present at a dam near a farm. Whether or not these boulders are derived from local granitic bodies is not clear but is highly probable.

Similar deposits occur about 20 km S at Tarrawingee (GR.445070, same map) except granitic clasts were absent and fossiliferous clasts were present. The Tarrawingee outcrop is on a hill and was referred to by Bowen (1960). Outcrop is in the form of surface concentrations of pebbles and cobbles which mainly consist of chert and sandstones. Rare fossiliferous clasts are multi-directionally striated and are composed of quite indurated sandstone. Non-fossiliferous striated sandstones are more common. The only clue to the subsurface nature of the deposit is the unbedded reddish-brown sandy gravelly clay soil exposed on the lower and mid-slopes of the hill.

About 22 km SW of Tarrawingee another four localities occur. One is the "Mundara" Hill locality referred to in the previous literature. The other three are not formerly mentioned in the literature but also appear on the Wangaratta geological mapsheet (SJ 55-2). The four localities are:

* "Mundara" GR.428497;
* Croppers Creek GR.428494;
* Factory Creek GR.429494;
* E of Factory Creek GR.433490.

(Royal Australian Survey Corps 1968, sheet SJ 55-2 series R502 topographic map 1:250.000, with 1972 amendments).

There is a wide range of rock types in the clast population but again indurated sandstones are by far the most common. Cherts are present but rare. Most clasts are pebble or cobble sized with very few boulders. At the "Mundara" site a well polished and unidirectionally striated boulder is exposed in a field containing many pebbles and cobbles (see plate 7, p.80). The soil in the field is a clayey sandy silt and grey to brownish in colour.

Further S, subdued hills contain deposits similar to those at "Mundara". It is possible some of these localities were known and described in previous literature but it is impossible to be sure because of the lack of detailed site descriptions. Fieldwork shows an area previously mapped as Carboniferous (GR.361517: Royal Australian Survey Corps[ed.1] 1973, sheet 8124, series R652 topographic map 1:100.000) contains substantial evidence of glacial deposition in the form of surface concentrations of pebbles, cobbles and rarer boulders some of which are either fossiliferous or striated or both. The striated clasts bear multi-directional striae rather than one dominant direction. Clasts are between 300 mm and 450 mm and are present at the base of the highest hill in the area (at spot height 198 m). At the same locality a small farm dam has been excavated near the base of the hill. The wall material provides the best indication of the subsurface material which is quite sandy and gravelly. West of the damsite, fields contain many fossiliferous pebbles and cobbles which are only recognised by well practiced eyes. Most of the fossiliferous clasts are composed of medium to fine grained sandstone. Soils in the surrounding area are gravelly (mostly granules and pebbles) sandy clays. The finer than sand fraction is estimated to be about 80%. The area is also characterised by a bench-like topography with steps of about 3 m. At about the expected

Plate 7 Glacially striated and polished boulder from weathered diamictite, at "Mundara" towards the southern end of the Ovens-King River Valley. (GR. 428497, RAS, sheet SJ 55-2, 1972 ammend., 1:250 000.

extension of one of the benches, the soils are distinctly bleached grey to whitish in colour and have a silky velvety feel indicating a high silt content. This soil texture is similar to that found at nearby outcrops of very weathered siltstones which are also associated with a bench-like topography.

Further surface concentrations of clasts are about 1 km S of Hansonville (GR.400488: Royal Australian Survey Corps[ed.1] 1973, sheet 8124 series R652 topographic map 1:100.000) and at another locality (GR.328477, same map) which is about 0.75 km further S. At the last mentioned locality, clasts mostly of chert and highly indurated sandstone boulders, are between 600 mm and 900 mm in diameter.

The final locality visited in the southern end of the Ovens-King River Valley is about 1.5 km NE of Greta South and again the geology of this area is indicated on the Wangaratta geological map (sheet SJ 55-2) as Carboniferous. indurated and softer well rounded fossiliferous sandstone pebbles are present at this locality (GR.333484, same map). Carboniferous sandstone crops out in nearby Fifteen Mile Creek and therefore the same area is probably underlain by Carboniferous but capped by remnants of Permian glacial sediments.

3.1.3 BEYOND THE SOUTHERN END OF THE OVENS-KING RIVER VALLEY (map 6)

South of Hansonville, toward the eastern side of the Tolmie Highlands there are about thirty small occurrences of Permian glacial deposits. Generally the outcrops are fair to poor and not very extensive but a few are quite good. Deposits consist of a few outcrops of a basal siltstone, overlain by some sandy beds which become conglomeratic toward the top and also contain some sandy lenses. In some areas all

that can be seen is the surface concentration of the gravel fraction overlying silty sandy clay soils. The real value of the deposits is again their contribution to the regional synthesis.

Throughout this area the proportion of multistriated and fossiliferous pebbles, cobbles and boulders is much higher than 50 km NE in the Wooragee Valley. The percentage of clasts with these attributes is estimated to be about 5% to 10% compared with about 1% in the Wooragee Valley (detailed discussion of the faunal assemblages will follow in chapter 4, p.122.)

About 3 km E of Hansonville, siltstones crop out in a small gulley (GR.384495, same map) and unfortunately the outcrop is not sufficiently well enough exposed to show any clear bedding. A large proportion of the outcrop is obscured by mud from the surrounding collapsed banks. The surrounding slopes and creek banks are composed of gravelly sandy clay soils. Pebbles, cobbles and boulders (some fossiliferous) are present at the surface; one boulder contains portion of a gasteropod.

Not far E of this locality, further outcrops of the same rock type and soils are present in and around another small creek. Still further outcrops are in the easternmost arm of the gulley. The siltstone is the most extensive bedded rock type in the area and also contains a number of cross-beds. The outcrop is discontinuous and is found from the fork in the creek (GR.495389, same map) almost to a glacial pavement located on a medium grained Carboniferous sandstone (GR.491390, same map).

The area of pavement exposed is about 1.5 m^2 and doubtless extends beneath the surrounding soil cover but would require substantial excavation: an exercise unlikely to meet with approval from the landowner. A variety of directional indicators are preserved on the

surface of the pavement and all suggest movement of ice from S to N. Only small scale cross-bedding and some contorted lamination is apparent in upward fining siltstone near the pavement but neither of these sedimentary features are well defined. The only attitudes which are measured with confidence are the plunge directions of cross-bed troughs and they are:

* 194° 259° x 2
* 199° 264°
* 239° 299° x 2
* 244°.

The siltstone is shown in plate 8, p.84.

The same easternmost gulley continues beyond the pavement where more discontinuous siltstone crops out in the bed and banks of the creek. At the head of the gulley (GR.390491, same map) about 1 m^2 of silty gravelly sandy clay is exposed but nearby a 3 m high bank of the same material forms sides of a former gulley course which is above the present gulley floor. A variety of pebbles and cobbles have been collected from the nearby high bank material: e.g. samples 77/34, 35, 36 and 37 (a rare silica replaced pisolitic limestone).

About 1 km W of the gulley head there are deposits consisting of concentrations of pebbles and cobbles which are mostly varieties of sandstones. Many of the clasts are fossiliferous and contain brachiopod and crinoid fragments, others consist of granite and indurated sandstone.

Plate 8 A view to the east showing cross-bedding in the Mohyu siltstone, downstream and 200 m north of the Moyhu glacial pavement. (GR. 495389 to 491390 RAS, sheet 8124, 1973) 1:100 000.

A small gulley about 0.5 km E of the glacial pavement contains about three outcrops of bedded glacial sediments. The landowner claimed part of the gulley for water storage dams during the course of fieldwork so that now some of the extensions of the best outcrops are under about 2 m to 3 m of water. The outcrops are discussed regardless of their present or likely future accessibility. Siltstone in this gulley contain small scale cross-bedding and some contorted lamination. Rare 5 mm diameter very well rounded clear quartz pebbles are present in some parts of the outcrop (GR. 396495, same map). Poorly exposed bedding has an attitude of $22^{o}/252^{o}$. The total thickness of this portion of the section is about 2 m. Further S up the gulley, siltstone is overlain by an interlayered unit which is mostly beige siltstone with interlayers of dark brown mudstone which is in some cases vaguely varved. The mudstone is poorly fissile in some parts of the section but for the most part is quite massive. An upper mudstone layer is about 3 cm thick and contains traces of charcoal which were identified by Dr. E Kemp (from the Bureau of Mineral Resources, Geology and Geophysics) during the course of a pollen search. Unfortunately, the mudstone examined was not pollen bearing. The lower mudstone layers are quite thin and distinct but one layer is about 8 cm thick. None proved to be pollen bearing and only traces of charcoal have been identified from this lower section of the outcrop. The higher layers of mudstone eventually grade into more weathered material in which the layering becomes too vague to trace confidently. The lower mudstones remain quite distinct; the lowest visible one is about 6 cm thick and contains rare pebbles and granules and has a bedding attitude of $8^{o}/225^{o}$. The mudstones is represented by samples 79/16.5a, b, c_1, c_2 and d; the siltstone is represented by samples 79/16.6, 30_a and 30_b. Cross-bedding present in the siltstone as

well as assymetrical (4 cm wavelength) ripples suggest that a current was present which flowed N and NW.

A variety of surface pebbles, cobbles and boulders are at the head of the same gulley further S. Near the remains of an old unused brick well, a large boulder clearly unidirectionally striated rests on the surface. It measures about 600 mm x 600 mm. At the top of the gulley where an east-west fence cuts across the field (GR.396409, same map) the landowner has collected a few hundred clasts from the surrounding field and has stacked them at the crown of the gulley to reduce erosion and to clear the fields of some of the larger rocks. Samples have been taken from this pile as well as from within a 200 m radius to provide an indication of the variety of clasts and also because of the richly fossiliferous nature of some of the clasts. Most of the clasts at the surface are pebbles and cobbles and many contain extremely well preserved faunal remains considering the softness of the rock types and the possible transport conditions which they have probably undergone. Brachiopod faunas are the most striking and obvious but other faunas are also present. The variety of clasts include chert of various colours, siltstones, silica cemented sandstones and conglomerates and some fragments of low grade regional metamorphics.

Within a large roughly circular depression which is about 100 m below the general ridge line and is about 1 km across, further outcrops of glacial sediments are exposed. The best of what is again rather poor outcrop is located in the banks and in the channel of a small ephemeral creek (GR.398488, same map). The lowest part of the exposure consists of a well cross-bedded gravelly coarse grained sandstone containing medium sized rounded to very well rounded quartz pebbles through to cobbles (from 10 mm to 100 mm). The plunge direction of the cross-beds

indicate the following directions for current motions which are uncorrected for dips:

* 174°
* 176°
* 179°
* 189°.

Toward the head of the gulley there is a noticeable fining of the sandstone from a coarse grained variety to a fine to very fine silty sandstone containing occassional 20 mm to 30 mm large pebbles. The sandstone is poorly cross-bedded and has a reddish to yellowish colour which is probably due to iron staining. Nearby in another part of the creek, sample 77/20 was collected which contains fragments of crinoid stems and separate ossicles.

About 0.75 km S, still within the "amphitheatre-like" depression, quite weathered very fine sandstone (or possibly coarse siltstone) crops out (GR.393474, Royal Australian Survey Corps [ed.1] 1973 , sheet 8124 series R652, topographic map 1:100.000). Nearby (Gr.395475 , same map) at the same elevation (270 m), acid porphyries, fragments of shale and fossiliferous cobbles and boulders are exposed. Associated with these clasts is a large block (about 1 m^3) of finely cross-bedded coarse silty very fine sandstone surrounded by black plastic clay derived from nearby weathering Tertiary basalt. The block may be dislodged but bedding planes within the block are consistent with other readings from the area (e.g., $30^{\circ}/199^{\circ}$) which argues against substantial re-orientation.

In the hills S of the previous outcrop, between the homesteads of "Avonlea" and "Dewrang" to the W, eleven small outcrops of glacial deposits have been recorded. Two outcrops of bedded sediments are exposed but the other occurrences are of the more usual surface concentrations of the gravel fraction. The only clue to the subsurface is contained within the erosion gullies where highly gravelly soils are exposed within the gulley walls. The clast variety in this area is indicated in the following list:

* Sandstone-both fossiliferous and not;
* Cherts-black and caramel are dominant;
* Acid igneous-mostly very weathered and not identified;
* Rhyolite;
* Porphyritic rhyolites;
* Rhyodacite;
* Porphyritic rhyodacite;
* Metamorphic rocks -mostly low grade regional and some higher grade mica schists; and
* some pebble and granule conglomerates.

The volcanics closely resemble those from the Tolmie igneous complex and are probably drived from that source (Dr. M.C. Brown, pers. comm.). The clasts vary greatly in size as well as rock type from each locality. Of the fossiliferous very fine sandstones (?siltstones?), by far the most common fauna contained are brachiopods and crinoid remains. The

most noted brachiopod is Notoconchidium thomasi because of its size and frequency.

At some localities cobbles and boulders are dominant whereas at others granules pebbles and cobbles are all present. To what extent this now reflects any original spatial variation of the gravel fraction is uncertain and could easily be a function of subsequent erosion of the deposits. Further surface concentrations are present at the following localities:

* 398474;
* 399473;
* 395465;
* 385465;
* 398451;
* 373450;
* 395446 and
* 390444.

Grid references taken from Royal Australian Survey Corps [ed.1] 1973, sheet 8124 series R652 topographic map 1:100.000.

Of the three bedded deposits in the area the most northerly is located on top of a ridge at the head of a gulley (GR.385460, same map). The deposit has a sandy silty gravelly clay texture and is considerably weathered but nevertheless in-situ. It is not well enough exposed to determine its thickness. The gravel fraction is dominated by small to

medium sized well rounded pebbles (4 mm to 16 mm). Their roundness is estimated to be between 0.7 and 0.9; their sphericity between 0.5 and 0.9. Further S, about 2 m of yellowish fine grained cross-bedded sandstone containing large (20 mm) pebbles crops out in a gulley (GR.390462, same map). The pebbles consist of clear and milky quartz and have a high degree of roundness (0.7 to 0.9) and a medium degree of sphericity (0.3 to 0.7). The sandstone is overlain by a conglomerate which is in turn overlain by a very fine sandstone further up the gulley (GR.387464, same map). Nearby on the east facing ridge slope (GR.390462, same map) beds with minor warping crop out. Cross-beds are present but are not very clearly defined and only a W sense of current direction can be interpreted. At the same outcrop clear dip and anti-dip slopes are present; the dip slopes face NNW. Cross-bedding troughs are exposed in the anti-dip face and give a sense of current direction N to NW. The rock type forming the outcrop is a very fine to fine sandstone (see sample 77/38) which becomes conglomeratic toward the base.

About 5 km SE along the ridge E of the "Willowbank" and "Avonlea" homesteads two separate surface concentrations of gravel fraction occur in which the most obvious clast size is between 50 mm and 500 mm. The clasts primarily consist of the following rock types:

* Rhyodacites;
* Acid porphyries; and
* various grained sandstones.

These deposits (GR.425435 and 428424, same map) are associated with basalts and bench-like topography. One similar deposit, except that

there is no association with basalt or bench-like topography, crops out about 2 km SSW of the "Dewrang" homestead. At this locality the dominant gravel fraction size is between 150 mm and 600 mm (large cobbles and boulders). The large boulders consist of silica cemented sandy pebbly conglomerate; chert; quartzite and some soft yellowish fine grained sandstone. All the clasts are very well rounded and very spherical, and have in each case values between 0.7 and 0.9. Igneous rocks have not been recognised but a few metamorphic clasts have been found (eg. samples 77/5a and 5c).

Four areas are now known further S near the high plateau area of Whitlands (AR.4329, same map). Three are in road cuttings in the mountains (GR.435307 and 435310, same map) and each represents about 20 m of section. The third outcrop is in another road cutting and is less spectacular than the others and is located about 400 m along the Myrrhee road (GR.436316, same map). This cutting consists of very weathered deposits which are texturally pebbly cobbly sandy clays. The total thickness of the section is about 2.5 m and also shows a crude pebble long axis orientation of 360°. Details of the other two cuttings are contained in a section to follow. Broadly, the sections consist of conglomerates, sandy beds and sandy lenses together with diamictites and boulder layers. Their gross appearance is shown in plates 9, p.92 and 31, p.115.

The fourth locality (GR.42675, same map) is on the Whitlands plateau at an area previously mapped as Carboniferous. Tertiary basalts cap the general area and form the plateau surface. Where the basalt has been stripped, glacial deposits are likely to crop out. The major outcrop at Whitlands is in the banks of a small farm dam that was built by scooping out the soft weathered bedrock composed of sandstones and sandy con-

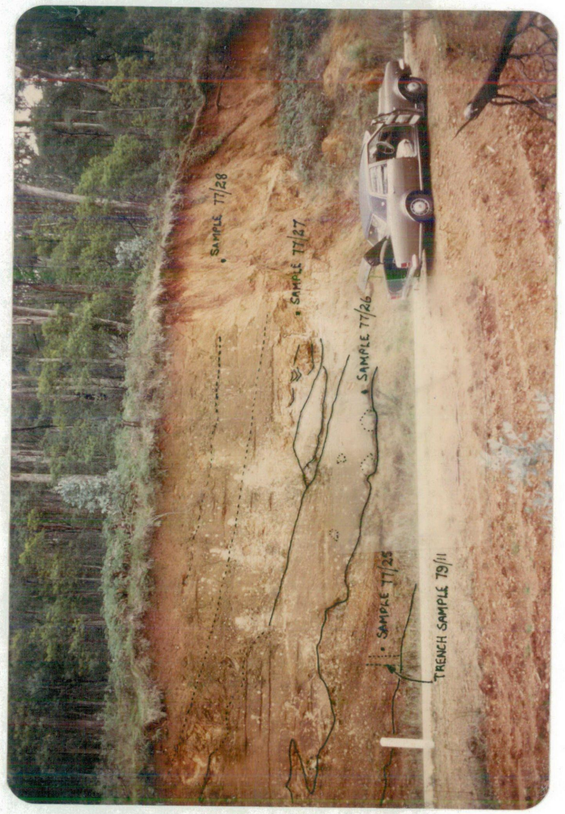
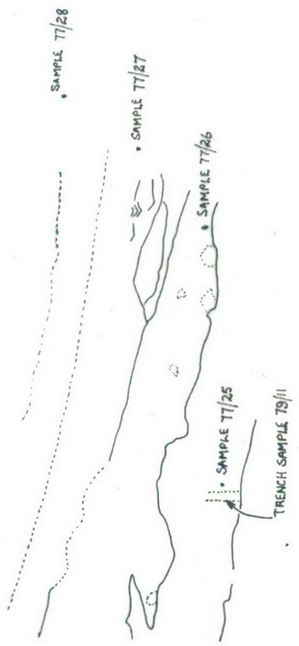
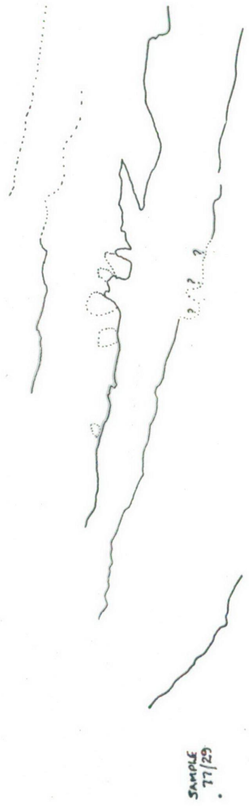


Plate 9a and 9b Stereoscopic pair of the lower Whitfield - Whitlands road cutting showing diamictite and interstratified traction deposits. (GR. 435307, RAS, sheet 8124 1973, 1:100 000.





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